

CLAIMS

1. A photodetector device comprising:

a multilayer structure including a plurality of compound semiconductor layers laminated and having first and second main faces opposing each other;

a photodetecting region formed near the first main face within the multilayer structure;

a first electrode arranged on the first main face of the multilayer structure and electrically connected to the photodetecting region;

a second electrode arranged on the second main face of the multilayer structure and electrically connected to the first electrode;

a third electrode arranged on the second main face of the multilayer structure and electrically connected to a part near the second main face in the multilayer structure; and

a light-transmitting layer, optically transparent to incident light and arranged on the first main face of the multilayer structure, covering the photodetecting region and first electrode.

2. A photodetector device according to claim 1, wherein the light-transmitting layer includes a film made of silicon oxide and a glass substrate; and

wherein the glass substrate is secured to the multilayer structure through the film made of silicon oxide.

3. A photodetector device according to claim 1, wherein the light-transmitting layer includes a film made of silicon oxide or a resin.

4. A photodetector device according to one of claims 1 to 3, wherein the plurality of compound semiconductor layers include a

high-concentration carrier layer of a first conductive type, a light-absorbing layer of the first conductive type, and a cap layer of the first conductive type; and

wherein the photodetecting region is a region of a second conductive type including at least a part of the cap layer.

5 5. A photodetector device according to claim 4, wherein the multilayer structure further comprises a depression formed about the photodetecting region, and a wiring electrode arranged within the depression;

10 wherein the first electrode is electrically connected to the second electrode through the wiring electrode; and

wherein the third electrode is electrically connected to a part positioned near the photodetecting region in the high-concentration carrier layer.

15 6. A photodetector device according to claim 4, further comprising a through lead penetrating through the multilayer structure;

wherein the first electrode is electrically connected to the second electrode through the wiring electrode; and

20 wherein the third electrode is electrically connected to the high-concentration carrier layer.

7. A photodetector device according to one of claims 1 to 6, wherein the second and third electrodes include respective pad electrodes, while respective bump electrodes are arranged on the pad electrodes.

25 8. A photodetector device according to one of claims 1 to 7, further comprising a light-reflecting film, provided on the second main face,

covering the photodetecting region.

9. A photodetector device according to one of claims 1 to 8, comprising a plurality of photodetecting regions arranged in a row.

10. A photodetector device according to one of claims 1 to 9, wherein the light-transmitting layer includes a lens part converging the incident light.

11. A method of manufacturing a semiconductor photodetector device, the method comprising the steps of:

preparing a semiconductor substrate;

providing a multilayer structure on the semiconductor substrate, the multilayer structure including a plurality of compound semiconductor layers laminated and having first and second main faces opposing each other, the second main face facing the semiconductor substrate;

forming a photodetecting region near the first main face within the multilayer structure;

providing a first electrode electrically connected to the photodetecting region onto the first main face of the multilayer structure;

forming a light-transmitting layer optically transparent to incident light onto the first main face of the multilayer structure so as to cover the photodetecting region and first electrode;

removing the semiconductor substrate after forming the light-transmitting layer; and

forming a second electrode electrically connected to the first electrode onto the second main face of the multilayer structure while

forming a third electrode electrically connected to a part near the second main face in the multilayer structure onto the second main face after removing the semiconductor substrate.

12. A method of manufacturing a semiconductor photodetector device according to claim 11, wherein the step of forming the light-transmitting layer includes the steps of:

forming a film made of silicon oxide so as to cover the photodetecting region and first electrode; and

securing a glass substrate optically transparent to the incident light onto the film made of silicon oxide.

13. A method of manufacturing a semiconductor photodetector device according to claim 11, wherein the step of forming the light-transmitting layer includes the step of forming a film made of silicon oxide or a resin so as to cover the photodetecting region and first electrode.

14. A method of manufacturing a semiconductor photodetector device according to one of claims 11 to 13, wherein the step of removing the semiconductor substrate includes the step of removing the semiconductor substrate by wet etching; and

wherein the step of forming the multilayer structure includes the step of forming an etching stop layer for stopping wet etching between the semiconductor substrate and the plurality of compound semiconductor layers.

15. A method of manufacturing a semiconductor photodetector device according to claim 14, further comprising the step of removing the etching stop layer by wet etching after removing the semiconductor

substrate.

16. A method of manufacturing a semiconductor photodetector device according to one of claims 11 to 15, wherein the plurality of compound semiconductor layers include a high-concentration carrier layer of a first conductive type, a light-absorbing layer of the first conductive type, and a cap layer of the first conductive type;

wherein the step of forming the multilayer structure includes the step of successively laminating the high-concentration carrier layer, light-absorbing layer, and cap layer on the semiconductor substrate; and

wherein the step of forming the photodetecting region includes the step of forming a region of a second conductive type including at least a part of the cap layer as the photodetecting region.

17. A method of manufacturing a semiconductor photodetector device according to claim 16, further comprising the steps of forming a depression about the photodetecting region; and

providing a wiring electrode for electrically connecting the first electrode to the second electrode in the depression;

wherein the step of forming the third electrode includes the step of forming the third electrode such that the third electrode is electrically connected to a part positioned near the photodetecting region in the high-concentration carrier layer.

18. A method of manufacturing a semiconductor photodetector device according to claim 16, wherein the step of forming the second electrode includes the step of forming a through lead penetrating through the multilayer structure, and electrically connecting the first electrode to the second electrode through the through lead; and

wherein the step of forming the third electrode includes the step of forming the third electrode such that the third electrode is electrically connected to the high-concentration carrier layer.

5 **19.** A method of manufacturing a semiconductor photodetector device according to one of claims 11 to 18, further comprising the step of forming a light-reflecting film covering the photodetecting region onto the second main face of the multilayer structure.

10 **20.** A method of manufacturing a semiconductor photodetector device according to one of claims 11 to 19, wherein the light-transmitting layer includes a lens part converging the incident light.